THE

SIDEREAL MESSENGER,

OR

MONTHLY REVIEW OF ASTRONOMY.

VOL. VII.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

NORTHFIELD, MINN.:
CARLETON COLLEGE OBSERVATORY.
1888.

ILLUSTRATIONS.

THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

JANUARY, 1888.

Thou Lord in the beginning hast laid the foundation of the earth and the heavens are the works of thy hands.

CONTENTS:

The Messenger will be published monthly except for July and August.

Subscription Price per year (ten numbers), $2.

Communications should be addressed to the Editor, Northfield, Minn.

NORTHFIELD, MINN.:

CARLETON COLLEGE OBSERVATORY.

Entered at the Post Office at Northfield, Minn., and admitted for transmission through the mails at second class rates.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 7, NO. 1. JANUARY, 1888. WHOLE NO. 61.

TOTAL SOLAR ECLIPSE, AUG. 19, 1887.

PROF. WM. HARKNESS, WASHINGTON, D. C.

THE following account of the total solar eclipse of Aug. 19, 1887, has been compiled from the best authorities yet available, and shows in a general way what extensive preparations were made for observing the eclipse, how far they were successful, and how largely they were defeated by the bad weather which prevailed throughout Germany and Russia. The stations are mentioned in the order in which they were passed by the moon's shadow, namely, from west to east:

German Stations. The Berlin observatory established stations near the central line of the eclipse at Inselberg in Thuringia, Luckenwalde, Steglitz six miles south of Berlin, Furstenwalde, Frankfurt on the Oder, and Allenstein in East Prussia; and also at Grünberg in Silesia, near the southern boundary, and at Britz near Eberswalde, on the northern boundary of the total zone. Dr. Förster, director of the observatory, occupied the station at Inselberg. Throughout all the region covered by these stations fog, rain, and clouds prevailed. At the extreme eastern stations the clouds in the east were strongly colored at day-break. As the sun neared the horizon the coloration first increased, then slowly diminished, until suddenly there came a complete and general obscuration, and after some minutes the coloration again appeared, only to be banished by full daylight. At Steglitz, a little before totality the observers were favored with a sight of the solar crescent for about five minutes, through a rift in the clouds. The totality itself was not seen, but during its continuance the darkness was so intense that a chronometer could only be read with difficulty, and α Persei, a star of the second magnitude, was visible in the zenith. An attempt was made by two members of the military ballooning department to pass through the clouds in a

balloon, but it failed. At Nordhausen and Eisleben, partially successful observations were made.

At Kleistshöhe, about an hour from Frankfurt on the Oder, were stationed Dr. Lachmann from the observatory of Breslau, Mr. Pechüle from Copenhagen, Prof. Tietjen from Berlin, and Dr. Neugebauer from Breslau. As the eclipse was hidden by the clouds, their observations were limited to noting that at the time of totality the northern horizon, to an altitude of about half a degree assumed a deep red tint, and the darkness became so intense that lanterns were required in order to see to read.

At Kolmar, in Posen, Dr. Korber from the Breslau observatory, and Prof. Reimann from Hirschberg, were stationed. Although the sky was covered by clouds, an attempt was made to record the times of third and fourth contact by noting the sudden changes in the light at the beginning and end of totality; and from these changes Dr. Korber concluded that the middle of the eclipse occurred within a second or two of $5h$ $19m$ $22s$ A. M., Breslau mean time. During totality there remained a red streak in the northern horizon, but the gloom was so deep that it was impossible to read the face of a watch without artificial light.

Breslau was not within the zone of totality, and it rained there during the eclipse, but notwithstanding these drawbacks Prof. Leonhard Weber made a careful series of photometric measurements of the daylight at the Breslau observatory.

At Goldap, in East Prussia, Prof. Th. Albrecht was stationed. Clouds rendered the eclipse invisible, but he determined the amount of light during totality in the following simple way: During totality he noted the greatest distance at which he could read a certain manuscript written with a lead pencil, and in the evening he watched for the time when the same manuscript was again just legible at the same distance, and found it to be forty minutes after sunset. Fortunately the condition of the sky with respect to cloudiness was the same in the evening as during the eclipse.

Russian Stations. At Wilna Mr. Paul Garnier was stationed. The weather was so bad that only two glimpses of the eclipse were obtained, one about thirteen minutes before, and the other about five minutes after, totality. During

totality some high cumulo-stratus clouds veiled the sun, but by noting the times when darkness came on and passed away the duration of totality was found to be very approximately 2*m* 13*s*. Some meteorological observations were also made.

At Ustpenskoie, eight miles east of Rschew, the Princeton College party was stationed. Prof. C. A. Young intended to make spectroscopic observations and observe "the flash" of bright lines at the instant of totality, while Prof. McNeill, Prof. Libby, and three ladies were to make photographs of the corona; but bad weather prevented them from seeing the eclipse. Capt. Witroffsky was also at this place.

At Spirowskaja totality appears to have been observed for twenty seconds.

At Twer a glimpse of the sun was obtained only twice during the eclipse; namely, at the contact, and when his disk was about seven-eighths obscured. The early dawn was beautifully clear, but soon a dense ground-mist involved the town, and when, a little before totality, enough wind arose to clear that away, a heavy bank of rain clouds put an end to all hopes of observation. It had been arranged that Professors Sverinzaff and Dschewetzki should ascend in a balloon—the former to take photographs, draw the contour of the corona, and measure photometrically the intensity of its light; the latter to draw the contour of the corona—but the experiment proved almost a failure. They left the earth twenty-five minutes before totality, but the balloon was met in its ascent by torrents of rain which collected in a large hollow at its top, and it never got through the thick rain which effectually obscured any view of the eclipse. The Messrs. Lewitzky, court photographers, alone obtained a photograph of the sun during the eclipse. It was taken about fifteen minutes before totality, in 0.005 of a second, with a diaphragm having an aperture as small as a pin's head; while during totality an exposure of two minutes with a diaphragm of 1.38 inches aperture was required in photographing the town of Twer.

At Sawidowskaja there were stationed Padre Conte Ferrari, and Messrs. Lais and Buti; all from Count Ferrari's private observatory at Rome. They were to make photographs of the corona and experiments on solar radiation

during the eclipse, but as the moment of that event approached, the sky became suddenly cloudy and the sun was not visible till noon. The actual instant of totality could only be noted by the intense darkness which suddenly spread over the whole district. Here and there a yellowish or leaden-gray tint could be distinguished in the clouds, presenting a most wierd appearance; and the strangeness of the scene was heightened by the profound disquiet and fear which seemed to have taken possession of the birds and cattle in the fields.

At a village on the Moscow railroad, fifteen miles from Sawidowskaja, Prince Gagarin succeeded in photographing the corona.

At Schipulino were stationed Prof. Hasselberg and Dr. Renz from the Pulkowa observatory, to make photographs and eye observations of the spectra of the sun and corona; Prof. Müller, Dr. Kempf, and Dr. Scheiner, from the Potsdam observatory, to photograph the corona by means of a special apparatus having a revolving slide to take eight pictures, and to make meteorological observations; and Dr. Donner, from the Helsingfors observatory, to search for intra-mercurial planets. Clouds prevented the eclipse from being seen.

At Wyssokoffsky were stationed Mr. Turner, from the Greenwich observatory, to make spectroscopic eye observations and photographs of the corona; and Count de la Baume, from Paris, to photograph the corona with a twelve-inch reflector. In mounting his instruments Mr. Turner had the advantage of the ample resources of a large spinning and weaving mill, which were generously placed at his disposal by Mr. Skidmore, the acting superintendent; but the cloudy sky made all his preparations vain.

At Klin, after a wet and cloudy night, patches of blue sky in the early morning raised delusive hopes, but during the eclipse the heavens were shrouded in dull gray, and a Scotch mist prevailed. To provide against that very contingency it had been arranged that Prof. Mendeleieff was to observe the form of the corona, its spectrum and the course of the moon's shadow from a balloon furnished by the Russian Imperial Institute of Technology, but the experiment was only partially successful. Partly because it was insufficiently

filled with gas, and partly because it was waterlogged by exposure to a heavy dew which had fallen in the early morning, when after much delay the balloon was cast loose it refused to ascend. According to one account Lieut. Kowanko, the aeronout who was to accompany Prof. Mendeleieff, thereupon got out of the car to make some necessary alterations, but on being relieved of his weight the balloon suddenly rose, and amid the hand-clapping of the crowd, the professor was carried away about two minutes before totality, begging his friends to collect his bones. Another account states that the professor—a man over sixty years old, who had never before been in a balloon—deliberately left the aeronaut behind him because the balloon could not carry both. Be that as it may, the balloon shot rapidly through the fog into the clear upper air, where, at an altitude of 11,500 feet, the professor had an excellent view of the corona, and saw the moon's shadow passing through the clouds, but his thoughts were necessarily so fully occupied with the unfamiliar task of managing the balloon that he had little time to give to scientific observations. He saw nothing of the earth for an hour, and, after traveling one hundred and twenty miles, he landed safely near the Serge monastery, not far from Moscow. In recognition of the pluck exhibited in this ascent, the Academy of Aerostation of France has presented a medal to Prof. Mendeleieff.

Messrs. Grassi, Colombo, and Stoppani, from Milan were stationed near Klin to make photometric observations of the corona.

At Nicholsk, twenty-five wersts from Podsolnitchnaya, Dr. Borgmann was stationed; and at Nikolikojo Messrs. Jegoroff, Wutschithoffsky, and party were established; but nothing was seen of the eclipse at either of these places.

At Elpatievo Narischkine, latitude 56° 58′, longitude 38° 07′ east from Greenwich, Mr. Il. Urech was stationed. Singularly enough, the sky was clear only during the eclipse, being cloudy both before and after. At 5*h* 45*m* A. M., local mean time, the sun emerged from the clouds. First contact, was observed at 5*h* 53*m*; second contact at 6*h* 52*m* 31*s*; third contact at 6*h* 54*m* 45*s*; and fourth contact at 7*h* 53*m*. During totality a magnificent corona and four red prominences were seen, and Regulus and Mercury shone brightly.

At Petrowsk, Prof. Glasenapp, of the St. Petersburg observatory, intended to make a specialty of searching for the supposed planet Vulcan, and for that purpose, as totality approached, he directed his comet-seeker upon α Leonis, close to the sun; but the presence of a thin, nebulous cloud prevented the prosecution of the search. He then turned his attention to the corona and obtained seven sketches and two photographs of it. In a letter to the *Novoe Vremya* he categorically asserts that his observations have led him to the positive conclusion that the corona is a real, and not an optical, appearance; and not, as some think, an illuminated shower of meteoric dust. Prof. Kowalsky, of St. Petersburg, obtained two photographs of the corona with an equatorially mounted portrait lens, of 6 inches aperture and 31.5 inches focus, by Secretan. Dr. Tatschaloff, of the St. Petersburg observatory, took some photographs of the corona; Dr. Stanoiewitsch, of the Meudon observatory, made photometrical determinations of its light by means of photography; and Prof. Kononovitsch, of Odessa, observed and photographed its spectrum, including the famous green line.

At Iwanowa Prof. Upton, of Brown University, Providence, R. I., Mr. Roatsch, and Dr. Köppen, of the Hamburg Seewarte, made meteorological observations for the purpose of determining the influence of the eclipse on the barometer. Some one hundred and seventy stations promised to cooperate with Prof. Upton in this work.

At Kineschma Prof. Bredichin, of the Moscow observatory, was stationed, and with him, by his special invitation, were Miss Brown of the Liverpool astronomical society, Rev. S. J. Perry of the Stonyhurst observatory, and Dr. Copeland of the Dun Echt observatory. The two latter gentlemen intended to photograph the corona and its spectrum, and to facilitate that work Prof. Bredichin had a Russian bath-house temporarily converted into a most spacious and commodious dark room—or rather a series of photographic rooms—with a copious supply of water. By the aid of generous help in every direction the party completed all their preparations in good season; but only disappointment awaited them. After some days of fine weather, the evening of the 18th had an ominous appearance, and on the morn-

ing of the 19th, although the sun was seen for a few minutes, the sky was covered with drifting scud, through which but a momentary glimpse of totality was obtained. Neither photographs nor spectroscopic observations could be obtained.

At Jurjewez, on the right bank of the Volga, were stationed Prof. Belopolsky of the Moscow observatory and Mr. Sternberg; Prof. Kortazzi of the Nicolaieff observatory; Dr. Niesten of the Brussels observatory; and the well known photographers, Dr. H. W. Vogel of Berlin, and Mr. Karelin of Nischnii Nowgorod. Both Belopolsky and Niesten were provided with cameras fitted to take four pictures simultaneously upon a single plate, and Karelin had a Ross portrait lens of six inches diameter. During most of the eclipse the sky was cloudy, but at the time of totality it cleared a little around the sun, and the chromosphere, prominences, and something of the corona, were visible. Totality began at 7*h* 10*m* 44.5*s*, local mean time, and ended at 7*h* 13*m* 11.6*s*, the sun's altitude being then almost twenty degrees. Dr. Niesten made a drawing of the corona which showed a strongly marked ray about a degree in length in the direction of the solar equator, and his assistant secured eight photographs, of which six were good. All showed the chromosphere and prominences, while two gave traces of the corona, and also of Regulus, which was near the sun. The exposures varied from eight to thirty seconds. With his six-inch portrait lens, and a drop shutter giving an exposure of 0.017 to 0.020 of a second, Mr. Karelin made an excellent picture of the corona, which is reproduced in Anthony's Photographic Bulletin for Oct. 22, 1887, page 614.

At Katunski the weather was fine, and the corona was seen in all its grandeur. The red prominences were visible to the naked eye.

At Warnawin Mr. Ceraski, of the Moscow observatory, was stationed, but saw nothing.

At Wjatka were stationed Mr. Doubjago of the Kazan observatory, and Mr. Kleiber; together with Prof. Tacchini of the observatory of the Roman College, and Prof. Ricco of the Palermo observatory, the two latter gentlemen intending to make spectroscopic observations. Clouds and rain prevented them from seeing the eclipse.

At Nolinsk it rained during the eclipse. The greatest darkness occurred about 7:45 A. M., and was like that of a moonless night.

From Perm nothing has been heard. Dr. Niesten of the Brussels observatory had intended to observe there, but owing to a delay in the transportation of his instruments he went to Jurjewez.

At Jekaterinburg the eclipse began in a cloudless sky at 7:25 A. M., and lasted till 9:30 A. M. The temperature fell from 66° F. to 55° at 8:37 A. M., and rose to 75° after the eclipse was over.

At Irbit the weather was fine. The totality began at 8:44 A. M., and lasted one and one-half minutes.

At Tomsk the weather was very fine and the sky clear. Totality occurred about 10:32 A. M., and the corona was most satisfactorily observed. Stars were visible, and the darkness was so great that in most houses it was necessary to light candles or lamps.

At Krasnojarsk Mr. Chamoutoff and party were stationed. The weather was fine and a number of important sketches and photographs of the corona were obtained.

At Irkutsk the sky was cloudless, and a good photograph of the corona was taken by Mr. Gabriel de Bohdanovithz.

In addition to the observations at stations close upon the central line, it was intended to make observations at a series of points near the northern and southern boundaries of the shadow, in order to determine the precise ratio of the apparent diameters of the sun and moon. The stations selected for that purpose, and the observers assigned to them, were as follows:

ON THE SOUTHERN BOUNDARY.		ON THE NORTHERN BOUNDARY.	
Stations.	Observers.	Stations.	Observers.
Soprikino......	Ludwig Struve.	Dunaburg....	A. Dollen.
Gschatzk.......	Lieut. Drischenko.	Velikie Luki..	Capt. Korloffski.
Moscow........	Wittram, Lorentzen.	Perovino......	Prof. O. Struve, Majeffski.
Vladimir........	Fuss, Sacharoff, Schubin.	Jaroslav.......	Lieut. Prince Galitzin.
Balachna.......	An assistant of Kortazzi.	Kostromo....	An assistant of Kortazzi.
Urshum.........	An assistant of Doubjago.	Orloff..........	An assistant of Doubjago.

Only one of these stations were favored with good weather.

At Shirakawa, Japan, on the site of an old castle burned in 1868, Prof. D. P. Todd, of Amherst College, was stationed with several assistants and a very complete outfit of instruments. During the forenoon preceding the eclipse the sky was almost perfectly clear, but about 1 P. M. a small white cloud appeared near the summits of the distant mountains, and before two o'clock it had spread upward to the zenith. Then dense black clouds arose in the east and south, and the beginning of the eclipse was entirely hidden. Shortly afterwards a few photographs of the solar crescent were taken through a rift, which soon closed up, and totality occurred amid peals of rolling thunder. Nothing whatever was seen of the corona or prominences, and during the remainder of the eclipse only a momentary glimpse of the solar crescent was obtained.

EXPERIMENTS WITH ELECTRICAL CONTACT APPARATUS FOR ASTRONOMICAL CLOCKS.

JAMES E. KEELER.

For the MESSENGER.

NEARLY all astronomical clocks are now provided by their makers with electrical apparatus for repeating the beats of the pendulum at a distance, and recording observations by the chronographic method. Various devices have been used for effecting this without disturbing the rate of the clock. With a gravity escapement the contact apparatus can be so adjusted that the extra work required for its operation is thrown on the train at the instant when the latter is detached from the pendulum, which is then entirely unaffected by the friction of the apparatus. With a dead beat escapement, which is still preferred by many of the best makers, it is impossible to use any kind of electrical attachment the effect of which will not reach the pendulum, and it is essential that the friction produced shall be constant.

Sometimes a clock has no electrical contact, or the apparatus provided by the maker is of faulty construction, and it is necessary to devise another more suitable form. In two admirable clocks by A. Hohwü of Amsterdam, which are mounted in the clock room of the Lick observatory, the electric circuit is broken by a small lever projecting from the

verge of the dead beat escapement, which at the extremity of the swing of the pendulum, lifts one edge of a light disk resting on three points. Two of these points are conductors, and form part of the electric circuit; the other is an insulating pin of ivory. The circuit is thus broken at intervals of two seconds, and the length of the break can be adjusted by raising or lowering an arm carrying the three points and disc. There is a relay inside the clock case for repeating the beats without sending powerful currents through the contact points. This apparatus, although of very beautiful workmanship, is constructed on erroneous principles, and, therefore, fails to perform properly. As the contact is broken at the extremity of the swing of the pendulum, small variations in the arc of the latter have a great effect upon the duration of the break, as have also slight changes in the relative positions of the lifting lever and movable disc, caused by expansion and contraction of the parts. In one of the clocks the maker has sought to remedy this defect by attaching the support of the disc to the clock frame as near to the verge as possible, but with only partial success. It is evident that to make the length of the break as short as is usually desired, a tenth of a second or less, the lifting of the disk must be extremely small, and the slightest cause is then sufficient to produce failure of the signals. The armature lever of the clock relay, instead of being light, is made large and heavy, so that it moves sluggishly, and does not respond quickly to the break. The relay is inside the clock case, which must be opened every time it is necessary to adjust the length of the signal. The same trouble has been experienced with these clocks in other observatories.* All this apparatus was removed after a few weeks' trial, and experiments were made with a view to finding some more reliable device which could be readily substituted for it.

The first experiment tried was with the very common arrangement of a knife edge, attached to the pendulum, swinging through a globule of mercury, and thus closing an electric current every second. This seems to work well in in most places, but it did not prove to be satisfactory here, probably on account of the extreme dryness of the air, which converts the slightest film of dust or oxide on the surface of

* Publications of the Washburn Observatory, Vol. I., p. 13, and Vol IV., p. 33.

the mercury into a non-conducting coating, causing the contact to fail. The platinum knife-edge must have considerable width, in order to give a sufficient duration to the current, and if good contact is not made at the instant the advancing edge touches the surface of the mercury, the second signals will be displaced on the chronograph sheet, and an erroneous record obtained. The globule of mercury had to be cleaned every time the clock was used, an operation not easily performed without disturbing the pendulum.

I next tried the experiment of replacing the platinum knife-edge by a similar one of copper, amalgamated on its lower edge with mercury, and lacquered elsewhere to prevent the mercury from spreading. Good contact was then secured, but the increase of friction due to the cohesion of the mercury surfaces was so great that it stopped the clock in a few hours. This was prevented by increasing the weight, which is very little more than sufficient to run the clock, but it was then found that the knife-edge carried away minute globules of mercury from the large drop, lowering the level of the latter and consequently altering the friction, so that the rate of the clock was not so good as before. The mercury contact was therefore rejected. In these experiments the knife-edge was placed near the middle of the pendulum rod.

The contact apparatus which I then tried, and which is still in use, is so simple and easily made, and has proved to be so satisfactory, that I have thought it worth while to give a description of it here, although there is nothing whatever of novelty in its principle. It resembles very much the old Saxton tilt-hammer, but has the important advantage over this of producing less friction with greater quickness and celerity of action.

A short piece of glass rod, less than a tenth of an inch in diameter, is cemented with sealing-wax into a tube soldered to a clip or half cylinder of very thin sheet brass, of such size that it tightly embraces the pendulum rod when sprung into place. This rod serves to break the circuit at every oscillation of the pendulum. The other part of the apparatus is carried by a plate of heavy brass, 4.25 inches long and 0.75 inches wide, screwed horizontally to the back of the clock case in a manner which will be described below. The edges of the plate are beveled. At the end farthest from the pen-

dulum is soldered a binding post, with one of its holes vertical. About half an inch from this is bored a round hole, into which fits a shoulder turned on a piece of brass tube one inch long and 0.3 inches in diameter. A long screw passing through the tube, and a washer at its outer end, holds the base plate against the back of the clock case, and forms a pivot about which the whole apparatus can be turned to adjust the length of break. To the outer end of the tube is soldered one end of a light steel spring 3.25 inches long, formed of part of the main spring of a watch. When the tube is in place the spring is parallel to the base plate. A fine needle is soldered to the free end of the spring on its lower side, and the joint is covered with a V shaped bit of sheet platinum. With care it is easy to solder these pieces without drawing the temper of the spring. The needle is bent at an angle of about 120°. To do this it must be slightly softened and the angle repolished with a little rouge.

At the other end of the base plate is an insulating pillar of wood about three-quarters of an inch long, held by a screw through the back of the plate. In the outer end of this pillar is inserted a short piece of stout platinum wire, to which, where it enters the wood, is soldered one end of a copper connecting wire, the other end leading to a binding post screwed into the back of the clock case about eight inches vertically above the binding post on the base plate. From these two posts lead the wires which connect with the clock its relay outside.

The V shaped piece of platinum on the spring rests upon the platinum wire on the end of the insulating pillar, and the pressure is adjusted by turning the tube to which the other end of the spring is attached. A very light pressure is sufficient to insure good contact. The glass pin on the pendulum rod is directed toward the back of the clock case, and at every oscillation of the pendulum lifts the spring by striking against the convex side of the needle, breaking an electric circuit through the clock relay every second. To make the length of break adjustable, a vertical slot is cut in the base plate near the wooden pillar, and the inner end of the plate is held by a short screw and washer through this slot. The amount of lifting of the spring can thus be made as small as desired. The spring arches slightly upward,

which depresses the angle in the needle to a more convenient level, and also gives more ready access to the adjusting screw just mentioned.

To prevent the oxidation of the platinum surfaces, a hard lead pencil is introduced between the binding posts which form the terminals of the contact apparatus, and held vertically between two pointed pieces of stout wire clamped by the binding posts. The lead is hollowed out a little at the ends of the pencil to admit the points of the wires. The extra current from the relay magnet passes through the core of the pencil, which has, however, so great a resistance, that the current constantly passing through the pencil and relay is too feeble to affect the armature of the latter. The pencil used with the above apparatus is a HHH Faber, and the clock relay has a resistance of five ohms. With a relay of greater resistance, a harder pencil would be required. This simple device forms a very efficient spark-preventer, and the platinum surfaces up to the present show no signs of oxidation. Is is much superior to a chronometer condenser which I used some time for the same purpose.

To make the arrangements complete, slow motion screws for adjusting would be required, but as no further attention is necessary when once the posts are in place, it seemed to me better to spend more time in the first adjustment than to complicate the apparatus. The friction of the glass rod on the spring is very small, even less than that of a knife edge swinging through mercury, as was shown by the smaller effect upon the arc of the pendulum. After a month's trial of this break-circuit attachment, I made a quite similar one for the other Hohwü clock, and they have both been in use now for more than six months, never failing to act promptly in that time. The rates of both clocks have been as good as with the original contact apparatus, and equal, perhaps, to the rate of any clock in the world.

A disadvantage of this contrivance, but one which is shared also by the mercury contact and the apparatus which was furnished by the maker, is that the zero second, or beginning of the minute, is not indicated in any way. For this reason a spring lifted by a toothed wheel on the second-hand arbor is more convenient. On account of irregularities in the wheel cutting, however, the intervals between

the breaks made by such an apparatus are not uniform, but differ often by several hundredths of a second, so that to get the best result from a comparison of two clocks whose daily rates vary only by quantities of this order, it is necessary to average a number of intervals in measuring the chronograph sheet. With the apparatus described above the intervals are of precisely the same length. To identify the zero seconds' column on the chronograph, a small switch is introduced in the circuit of the clock relay, in a convenient position near the clock case, and the zero second of any minute is cut out by hand.

THE PLACE OF ASTRONOMY AMONG THE SCIENCES.*

PROF. SIMON NEWCOMB.

It is often said that we live in an age of specialties. Two or three centuries ago a learned man was master of all the knowledge of his time. That learned man, however, has disappeared, and in his place has come the master of a special branch. There wrs a period of several centuries in which we had astronomers, physiologists, physicists, and philologists, but we might almost say that these classes are disappearing and giving way to the students of branches so remote from each other that one can scarcely know what another is doing. He who would now be a master even in the minutest branch, must devote an enormous number of energies to its cultivation. In mathematics each particular branch is studied almost exclusively by some one or two of its votaries. In medicine the general physician is rapidly giving way to the specialist; and even in philology one is generally the student of some particular language which he makes a specialty. When we see a self-dividing process like this going on generation after generation we are naturally led to inquire where it will lead to and how it will stop. We all recognize the usefulness of knowledge in society; but of what use to society will that kind of knowledge be which is confined to one or a few investigators, and which it is impossible, perhaps, for them to indicate to any large body of ther fellow men? We must look to

* Address delivered at the dedication of the new observatory of the University of Syracuse, N. Y., Nov. 18, 1887.

the scientific publications of the day to answer this question, and see the character which they present to us. It is a recognized fact that the man of science works for the good of society and posterity, and so he must publish what he learns. That is why we find such an increase in our libraries of periodical literature. The mere titles of the scientific periodicals which have appeared during the last three hundred years fill a good sized printer's volume; not the titles of books, but of serials devoted to the publication of original investigations and really new additions to human knowledge. We may admit that far the greater number of these serials are of but local or temporary interest; but if we take only those which are intended to add to the world's permanent advances of knowledge we shall still find the number to be appalling. And we have not only these scores of scientific periodicals which abound in every country, but we have scores, or perhaps hundreds of learned societies, who publish volumes which are supposed to contain nothing but important additions to human knowledge. We have in the department of mathematics alone one serial in America and two or three in each of the great countries in Europe. Altogether there are perhaps more than a dozen volumes issued annually in the department of astronomy. The leading astronomical journal of the world was established about 1824; during the earlier years of its existence about one volume appeared annually; now its 118th volume is in progress, and the series is going on at the rate of three volumes a year, with an unmistakable tendency towards an increase as the years go on. The Royal Astronomical Society of London publishes two volumes annually. And how many other societies there are through England and Europe which add to the number, it would be hard to say.

How will it be in the future? You will pardon an astronomer if he looks a long ways ahead, because he is accustomed to dealing with long intervals of time. We cannot set any limits to the duration of our earth or the time the human race may live upon it, but still let us look ahead at what is astronomically the very short interval of 1,000 years. What will the astronomer do when he has to consult Vol. 2,000 or 3,000 of the Greenwich Observations? By strict industry the students can now generally find out what is

going in on any one subject, but what will he do when the volumes are counted by thousands when perhaps an index alone will nearly fill a library? Even now it is almost impossible to determine whether a general result reached is a new one, unless the investigator has gone out into some entirely new field where he knows no one has preceded him. So, perhaps, in time, the discoverer of something new in an old book will be equally meritorious with the discoverer of a new law of nature.

You may naturally inquire how it is possible to write so much on so small a subject, or how so much can be written on a subject of scientific knowledge. I recollect a visitor once said to me he did not see how the astronomers could find anything to do, he thought the study of the movements of the heavenly bodies had already been exhausted. Now let us in imagination visit an observatory. We see before us a large collection of instruments—telescopes, spectroscopes, micrometers, sextants, etc. Out of these let us select the most modest-looking—perhaps it is a spectroscope; let us take it to pieces and find the smallest and most insignificant part. Perhaps the simplest portion will be the glass prism through which the light is sent. Apparently we shall then hold in our hands nothing but a very small piece of glass, triangular and polished on two of its faces. Surely here is something about which very little is to be said. However not only is there a great deal to be known on the subject, but as a matter of fact it may well happen that you cannot find in the whole body of literature something which the astronomer may desire to know about this little prism. One subject of investigation is its refracting power in regard to various colors and lights. It requires great skill in the handling of the apparatus with which the measures are made. Only a few years ago I had to make an investigation concerning the great Lick telescope of California, in regard to the various kinds of flint and crown glass. I was unable to find an entirely satisfactory explanation of their refracting powers in any publication. Equally complex and difficult is the investigation of the influence which this little piece of glass exerts upon the various kinds of light and heat which pass through it. Ordinarily we have been concerned with the action exercised by the prism upon the light; but now

within the last few years an eminent American astronomer has gone into the question of the heat rays absorbed by this glass, and the results he has obtained about transmissibility of heat through glass are creating almost a new branch of investigation, having important bearing upon the meteorology of our globe. The specific gravity and chemical constitution of the glass also are to be carefully determined with a view to determining the action of light upon different kinds of glass. Equally important is the kind of glass. Equally difficult is the question how to shape and polish the glass so that its faces shall be perfect mathematical planes. Perhaps the investigator will find that each edge of the glass is a little curved towards its edge, so that its action towards the rays of light is not what it ought to be. Finally, when the astronomer has brought the glass to completion and in working order, how he shall keep it from dust and the action of time and deterioration from the action of the elements is an important question. Now, if the simplest piece of glass in the smallest instrument of the observatory can be the subject of such a mass of investigation, by what shall we measure the amountof study required by all the instruments in every department of astronomy and physics?

If this constant subdivision of specialties were all we could look forward to, we might inquire if, after all, we were not going a little too fast on the road to learning. The ultimate result will be that our time will be entirely absorbed in the study of some one thing, much as in the division of labor it was said the whole of one man's life was spent in making the tenth part of a pin. But science has an exploring work of a higher order than that of investigating spectroscopes and quadrants. It is one of the great advantages of science which gives especial interest to much of our investigation, that the great multitude of facts which we discover from time to time have their origin in a few simple laws. The fundamental idea on which the scientific man investigates nature is that there is a uniform plan back of everything which is capable of being grasped by the human mind; and however complex the phenomenon may appear to be in its form, there is some simple cause, which, if we only knew, we should be able to trace out without going through the laborious process of examining every detail. But the sciences

are growing more and more alike in their form; the ultimate result will be that the plan of nature will be presented to us in a series of mathematical formulæ, by which we shall be able to understand the result without laboriously consulting every detail. In the first stage of every science the study of details is, from the very nature of the case, the most conspicuous part of the process. But we are never satisfied with these details until they carry us back to their general laws. The fundamental principles of astronomy are simpler now than when that celebrated Spanish monarch said that if he had been consulted on the construction of the heavens he would have made them on a simpler plan.

In the days of Ptolemy the whole geometry of the heavens was on a simpler plan than when that monarch lived; now, however, the whole complexity of motion in the solar system is traced back to the law that every body attracts every other body with a force as the inverse square of the distance and directly as the product of the masses. Given those two laws, and the mathematical ability to ascertain their results, and the details all disappear, giving place to the general law which can be grasped by any mind properly trained for the purpose.

We see the same tendency in many other branches of science. The leading phenomena of electricity are now traced back to a few first principles. So with chemical subjects. The first result is, the mathematical study of every science will be found to be the uttermost. Even in subjects of such complexity and apparently so far removed from general laws as biology and zoölogy, the same tendency is observable. The method of studying organic life has undergone a great change in the last twenty years. In the last generation the biological text book consisted of a labored plan of each animal described in barbarous Latin. We now not only study animals in their individual history, but in the origin of their qualities, showing how the various peculiarities which we notice originated. So, every science should be studied in the same way, the ultimate end being to understand it, not in its multiplicity of details, but as you understand the branches of a tree; the root or the stem being the prominent part, while the branches are merely the details and belong to the stem. And though it is impossible

for any one to master all the principles on which the results of general law are worked out, yet that faith in the unity of nature which is implanted in the breast of every studious man will lead us to believe that the integrating progress will outgrow the disintegration.

The lesson we draw from these tendencies of science will now be clear to you. There is something more than the mere investigation of multitudinous details, such as those which I have described. It is in astronomy that the integrating process is most fully seen. It has been called the most perfect of the sciences. As I have already said, all the geometry and astronomy, all the phenomena of the motions of the heavenly bodies are already reduced to one general law.

I now desire to say something upon its dignity and its historical character. Every well constituted mind enjoys the flavor of antiquity. Nothing more impresses the visitor to the Coliseum than the reflection that around the very arena where he stands, the walls of which he is looking at, echoed 1,000 years, or 1,500 years ago the plaudits of the Roman people as they viewed the contesting gladiators in the arena. As he looks at the opening on one side, which the guide will tell him was reserved for the entrance of the Cæsars, he cannot but be impressed with the might of the period. The reigning nobility of all the people of Europe take a just pride in tracing back their ancestry unbroken through centuries. Now, the astronomer may take the same pride in tracing back his intellectual descent from Hipparchus and Ptolemy through an unbroken series of workers from the dawn of history to our own time.

I know it is very common to speak with contempt of the ideas of the ancient astronomers. When a man to-day wishes to picture an idea as being entirely behind the age he compares it with the Ptolemaic age; and writers sometimes tell us the ancients did not know the earth was round. Now, I am here this morning to vindicate the character of our ancient ancestors. The fact is, the Ptolemaic age sent forth, not only the most wonderful production of the human intellect, but principles which are now, to-day, at the foundation of astronomy. How unjust is the popular notion of Ptolemy will be seen by merely noting how well he could

predict the motions of the heavens. Let us suppose the writer who lived in the year 150 of our era had been told that to-day in a distant city of another hemisphere which he had never seen, an audience would be assembled to discuss his favorite science, and that for the benefit of that audience he was requested to prepare an account of how the heavens would look to-day in our eyes. Through the seventeen or eighteen centuries which have intervened he would correctly calculate every revolution of the earth and tell us to-day when the moon would change, and what its aspect would be, with an error of only about two hours. If he had been asked what eclipses would occur during this year, he would have told that on the 18th of August there would be an eclipse of the sun in certain parts of the world. He could not have told, perhaps, that it would pass through Siberia and Japan, because he did not know there were any Siberia and Japan, but he would have made a map and shown where the eclipse would pass within about 20 degrees of longitude. So with the position and aspects of each planet. He could have told you where we could to-night see Jupiter and Saturn, with an error of only a few degrees, and would have predicted the time of their rising within about half an hour.

[TO BE CONTINUED.]

A NOTE ON THE DISTRIBUTION OF THE STARS.

W. H. S. MONCK, DUBLIN.

For the MESSENGER.

THE distribution of the stars is a very wide subject and it is only with a small branch of it that I propose to deal. I found it, however, not easy to define this branch in the title of my paper. My object is to compare some well-known catalogues of star-magnitudes with the results derived from the hypothesis of uniform distribution so as to see to what extent and in what manner the actual results differ from those deduced from this hypothesis.

If the stars are uniformly distributed round the sun and are all of equal mass and brilliancy, it is easy to compute the proportion which would exist between the numbers of stars of different magnitudes. Draw a series of spheres around the sun with different radii. Then the number of

stars which would be cut by, or would lie close to, the surface of each of these spheres, would be proportional to the spherical surfaces themselves. They would therefore be proportional to the squares of the respective radii. But the light of each star as seen by us would vary inversely as the square of its distance—that is, inversely as the squares of the respective radii. The number of stars would therefore be increased in exactly the same proportion that the light of each star was diminished: and the total light received from each sphere-surface would be the same. This reasoning, indeed, involves two assumptions: viz., that no pair of stars lies precisely in the same direction so that one would intercept the light of another, and that there is no medium in space which absorbs light. And before proceeding further, I desire to say that either the hypothesis of uniformity itself or else one of these assumptions must differ very widely from the truth, not merely in detail, but in the general average result. For we could otherwise go on drawing sphere beyond sphere to infinity receiving an equal quantity of light from each, and the sum total of the starlight received would be enormously greater than that received from 1,000,000 of the nearest and brightest stars. There are good grounds, I think, for concluding either that the stars known to us form part of one great cluster, beyond which there is a comparative void, or else that there is a medium in space which intercepts light.

It is now conceded that our ordinary estimates of star-magnitudes are best represented by a geometrical ratio. But we can hardly rely on the results as agreeing precisely with such a ratio defined by a constant number except where the stars have been photometrically measured, this number being adopted as the basis of arrangement. This has been done in the *Harvard Photometry* and in the *Uranometria Nova Oxoniensis*, the constant ratio adopted in both cases being 2.512 for each magnitude. If we subdivide the stars in these catalogues to such an extent that the stars in each sub-division may, on the hypothesis of uniformity, be regarded as equidistant, then if that hypothesis be correct the numbers of the stars comprised in these successive sub-divisions should form a geometrical series with a constant ratio. I adopted one-tenth of a magnitude for my unit of sub-division,

and it is easily shown that if the constant ratio for one magnitude be 2.512 the corresponding ratio for one-tenth of a magnitude is 1.0965. Thus if the number of stars rated at 4.5 to 4.6 was 100 and the distribution was uniform, the number rated at 4.6 to 4.7 would be 109 (or rather 110); the number rated at 4.7 to 4.8, 120; the number rated at 4.8 to 4.9, 132; and so on, until finally the number rated at 5.5 to 5.6 would be 251. Moreover from the number of stars comprised in any particular sub-division we could compute the entire number of brighter stars, since a decreasing geometrical series can be summed although carried on to infinity. The sum of the series $ax + ax^2 + ax^3 +$ etc., *ad infinitum* is $\frac{ax}{1-x}$, or since x is here $= \frac{1}{1.0965} = 10.363a$; and in the case which I have taken as an illustration the total number of stars brighter than the 4.5th magnitude should be 1,036.

Neither the Harvard nor the Oxford catalogues are complete. The former contains no stars whose southern declination is greater than 30°, while the Oxford list stops at a southern declination of 10°. The Harvard catalogue is thus preferable as including a larger portion of the heavens and a greater number of stars, and there is, I think, some reason for believing that its estimates of magnitude are also more reliable. Both catalogues are incomplete in another way. They do not contain all the stars down to the point at which they stop in their descent in the scale of magnitudes: and I am somewhat at a loss to know down to what sub-division I can regard them as complete in this respect. The maximum number of stars in any of my sub-divisions in the Harvard catalogue occurs between 5.7 and 5.8. From 5.8 to 5.9 there is a small decline which becomes more rapid as we proceed lower. The maximum number in the Oxford list occurs between 6.0 and 6.1, below which point the decline is still more rapid. Probably the sub-division 6.0 to 6.1 in the Oxford list corresponds most nearly with that from 5.9 to 6.0 in the Harvard, but the Oxford maximum would thus coincide with a considerable decline at Harvard. The conclusion to be drawn from these results is, I think, that the Harvard list cannot be relied on as containing all the stars below the 5.8th magnitude, while the Oxford list is similarly defective below the 6.1 magnitude. Of course it is useless to

institute a comparison between the actual and theoretical numbers of stars comprised in any sub-division unless the actual number includes all the stars which ought to be included, *i. e.* all comprised in the sub-division which lie in the portion of the sky observed. Not feeling confident of this below the points mentioned I did not use the catalogues beyond these limits.

The following table may contain a few errors of transcription but nothing to affect the general result. It contains the stars in each sub-division from 1.5 onward according to Harvard and Oxford respectively:

Magnitudes.	No. of Stars (Harvard.)	No. of Stars (Oxford.)	Magnitudes.	No. of Stars (Harvard.)	No. of Stars (Oxford.)
1.5 to 1.6	1	1	3.9 to 4.0	43	23
1.6 to 1.7	1	0	4.0 to 4.1	35	20
1.7 to 1.8	2	3	4.1 to 4.2	46	31
1.8 to 1.9	4	4	4.2 to 4.3	52	33
1.9 to 2.0	3	3	4.3 to 4.4	59	37
2.0 to 2.1	7	5	4.4 to 4.5	72	44
2.1 to 2.2	7	6	4.5 to 4.6	71	39
2.2 to 2.3	5	6	4.6 to 4.7	86	57
2.3 to 2.4	8	2	4.7 to 4.8	95	58
2.4 to 2.5	3	9	4.8 to 4.9	95	58
2.5 to 2.6	5	3	9.9 to 5.0	130	90
2.6 to 2.7	6	5	5.0 to 5.1	142	136
2.7 to 2.8	10	5	5.1 to 5.2	153	105
2.8 to 2.9	11	4	5.2 to 5.3	167	111
2.9 to 3.0	9	4	5.3 to 5.4	183	121
3.0 to 3.1	18	13	5.4 to 5.5	200	142
3.0 to 3.2	18	10	5.5 to 5.6	227	157
3.2 to 3.3	10	11	5.6 to 5.7	248	179
3.3 to 3.4	17	11	5.7 to 5.8	284	172
3.4 to 3.5	18	14	5.8 to 5.9	(279)	148
3.5 to 3.6	21	21	5.9 to 6.0	(235)	162
3.6 to 3.7	22	24	6.0 to 6.1	(207)	239
3.7 to 3.8	33	13	6.1 to 6.2	(179)	(117)
3.8 to 3.9	29	21			

A glance will show that the Oxford table presents many more anomalies than the Harvard, though some unexpected features are common to both. Among these are the exact equality of the numbers between 4.7 and 4.8, and 4.8 and 4.9, and the very considerable increase which follows between 4.9 and 5.0. So, too, we have the comparative paucity of stars between 2.3 and 2.6 as compared with the three preceding sub-divisions and the decline instead of increase at 4.0 to 4.1.

We might expect that where the number of stars was small considerable deviations from the law suggested by the hypothesis of uniformity would appear; but that, when the numbers were larger, in the absence of some special cause, the deviations in opposite directions would tend to balance each other and the results would be in fair accordance with the law. In portions of the Harvard list this expectation is realized. The closest approach is in the portion from 4.9 to 5.8 (the lowest point at which I regard the Harvard catalogue complete). In the following table I have endeavored to distribute the same number of stars in geometrical progression with a common ratio of 1.0965 in the column headed "Computed" but in avoiding fractions the totals are not quite identical:

Magnitudes.	Observed (Harvard) No. of Stars.	Computed No. of Stars.
4.9 to 5-0	130	128
5.0 to 5.1	142	140
5.1 to 5.2	153	154
5.2 to 5.3	167	169
5.3 to 5.4	183	185
5.4 to 5.5	200	203
5.5 to 5.6	227	222
5.6 to 5.7	248	244
5.7 to 5.8	284	267
(5.8 to 5.9)	(275)	(293)

The Oxford catalogue affords a tolerably close approach to the law during a portion of the same stage. I have not deemed it necessary to write out any other tables. There is however, some degree of approximation to the law almost throughout the whole extent of the Harvard catalogue, subject to one remarkable qualification: viz., that *the number of stars* (with occasional fluctuations) *increases more rapidly than the law of uniformity will account for*, and therefore to keep level with the actual number of stars he must from time to time raise the ratio. For example, from 3.9 to 4.9 we get a tolerable approximation to the number of stars actually observed (at Harvard), by dividing the figures in the above table by 3 instead 2.512, the theoretical divisor; from 2.09 to 3.9 again we obtained a fair approximation by dividing by 10 instead of the theoretical value of $(2.512)^2$ or 6.310; and for those between 1.9 and 3.9 we may divide by 30 instead the theoretical $(2.611)^3$ or 15.851, the stars lying between 3.9 and 4.9 being thus nearly twice as numerous relatively to those between 1.9 and 2.9 as if the law of uniformity held

good throughout. The Oxford catalogue here exhibits similar results, the best divisions for it being 3.4, 10, and 28 respectively. And that the same rule applies to stars below the 1.9 magnitude may be shown by summing the series in the manner already explained. Re-distributing the stars between 1.9 and 2.9 in accordance with the law of uniformity the number which best represents the interval 1.9 to 2.0 is 4. It will suffice for my purpose, however, to take the actual number (in the Harvard catalogue), which is 3. According to law of uniformity the number of brighter stars ought to be 31, but it is in fact only 24. And here too a similar result might be deduced from the Oxford list. I give the numbers from the two catalogues from somewhat wider intervals than before, in order to explain this:

Limits.	No. in Harvard List.	No. in Oxford List.
Brighter than 1.9	24	22
1.9 to 2.9	65	48
2.9 to 3.9	195	142
3.9 to 4.9	654	400
4.9 to 5.9	2,009	1,351

On the hypothesis of uniformity the ratio between the first and second of these numbers should be about 1.50, and that between each succeding pair, 2.512. It will be seen that these ratios are in all cases exceeded. It seems to follow that we are at present traveling through a region somewhat barren of stars, which is surrounded by regions of greater richness, this richness constantly increasing up to the mean distance of a star of the 6th magnitude, if not beyond it. This richer star-region may have produced effects on the climate of the earth in the remote past, and may do so again in the remote future.

[TO BE CONTINUED.]

THE SYSTEM OF SIRIUS.

REV. NEWTON M. MANN.

For the MESSENGER.

THE Dog-star has fairly resumed its ancient pre-eminence in human interest. It has for the great telescopes, on account of its companion even more than the charm which, from its transcendent brightness, it has ever had for the naked eye. And for the student of double-star motions, it

easily holds the first place as well for the enormous mass of the system as the comparative brevity of its period.

In the SIDEREAL MESSENGER for August, 1883, I presented some work which I had done on this star, and which I wish now to correct and supplement. The extension of the known arc of revolution, then needed definitely to establish the orbit, has now been made, and I present with more confidence the results which I have reached. The positions fixed upon are:

1863.919	80°	1878.526	50°
1868.484	70°	1883.001	40°
1873.452	60°	1886.112	30°

An ellipse drawn from these epochs and angles alone gives as elements of the orbit:

Semi-axis major,	21″.8
Position of periastron,	257°40′
Inclination,	75°.5
Position of node,	188°
Eccentricity,	0.945
Period,	51.22 years.
Time of Periastron-passage,	1890.55

This result compared with the observations of angle is very satisfactory, as may be seen from the table at the end of this note; but the observed distances introduce another problem. To harmonize these with the observed angles, it needs to take into account the motion of the principal star, which, in the case of so eccentric an orbit, becomes a very important consideration.

Consulting the measures of distance only for about the time the companion was at its widest apparent remove, I found the distance corresponding to the angular position of 60° to be 11″.50. The distances then at intervals of 10° become:

At 80°	10″.48	At 50°	11″.26
At 70°	11″.17	At 40°	10″.04
At 60°	11″.50	At 30°	7″.79

Charting the observed distances, I found them departing from this curve by an increasing difference as the distance decreases, falling short at 30° as much as 0″.75. This divergence must be the key to the motion of the principal star, and so to the relative mass of the two.

Comparing the figures in the above table of distances from 60° on, we find the computed distance decreasing at the

three following stages by 0″.24, 1″.22, and 2″.25. These figures represent the approach of the companion toward the centre of the system, but there is a discrepancy at the last step from the observations of 0″.75, or one-third of the 2″.25, and therefore the motion of the principal star is one third that of the other.

The table of distances then may be reconstructed thus:

Position. Angle.	D. comp. as above.	Approach of Comes to Centre.	Approach of Sirius.	Distance from Star to Star.
60°	11″.50			11″.50
50°	11″.26	0″.24	0″.08	11″.18
40°	10″.04	1″.22	0″.41	9″.63
30°	7″.70	2″.25	0″.75	7″.04

The same principle applied to the two preceding points gives their distances 10″.25 and 11″.06 respectively. The discrepancy between the curve indicated by angles and epochs, and that indicated by measures of distance is such as to imply that the principal star is moving in an ellipse one-third the diameter of that in which the companion is moving. In 1874.211 the pair were at their greatest apparent distance, 11″.52; their apparent distances then from the centre of the system was 8″.64 and 2″.38. Calculation of the orbit from angles and epochs alone gives only the distance (proportionally) from the centre of the system. The marked departure of such calculation from the measures of distance, is resolved by taking into account the motion of the principal star. As the companion moves toward its periastron, not only is its distance from the centre of the system shortening, but the distance also of the principal star from that point is shortening. at a rate uniformly one-third as great.

This implies, of course, that the mass of the companion amounts to one-fourth the mass of the system.

How far this motion of Sirius goes to answer for the perturbations long observed in that star, I leave for those better versed on that subject. But I call attention to the fact that assigning to the companion one-fourth that of the system harmonizes well with the observations. Indeed, I venture to say they can no otherwise be harmonized. Subjoined is a comparison with sixty-four observations that I have at hand. A few others have been rejected for obviously excessive inaccuracy. As the principal point in this discussion turns on the measures of distance, I call particular attention to the comparison in that regard:

OBSERVER.	TIME.	θo.	θo.—θc.	R.	R. o.—R. c.
A. Clark	1862.08	85.0	+0.5°	10.00″	+0.12″
Bond	.19	84.6	+0.3	10.07	+0.17
Challis	.23	85.0	+0.8	10.42	+0.52
Lassell	.28	83.9	−0.1	....	....
Rutherford	3.10	81.2	−0.8	....	....
Mitchell	.20	79.2	−2.5	10.40	+0.52
O. Struve	.21	82.5	+0.8	10.14	+0.02
Dawes	.23	....	....	10.00	−0.12
Winnecke	.24	79.7	−1.9	....	....
Bond	.27	82.8	+1.2	....	....
Lassell	4.15	80.3	+0.8	9.53	−0.77
Lassell	.21	80.1	+0.8	9.67	−0.65
O. Struve	.22	79.5	+0.2	10.92	+0.60
O. Struve	5.20	77.2	+0.1	10.60	+0.11
Forster	.22	77.9	+0.9	10.78	+0.28
Struve	.24	73.7	−3.3	10.79	+0.29
Tietzen	.25	76.8	−0.2	....	....
Englemann	.26	76.9	0.0	....	....
Bond	.26	76.0	−0.9	....	....
Struve	.70	73.7	−2.2	....	....
Knott	6.08	77.1	+2.0	10.43	−0.22
Tietzen	.20	76.8	+1.9	10.97	+0.30
Bruhns	.20	....	....	10.74	+0.07
O. Struve	.20	75.2	+0.3	10.93	+0.26
Washington observatory.	.23	74.3	−0.5	10.21	−0.47
Washington observatory.	.25	74.3	−0.4	10.65	−0.03
O. Struve	7.22	72.1	−0.6	10.98	+0.14
Forster	.24	72.3	−0.3	....	....
Brahns	8.24	69.5	−1.0	11.35	+0.33
Englemann	.26	71.6	+1.1	10.95	−0.07
Brunnon	1869.10	....	....	11.26	+0.10
Vogel	.15	....	....	11.23	+0.06
Duner	71.22	64.1	−0.3	10.92	−0.47
Pechule	.25	....	....	12.10	+0.71
Duner	2.18	59.8	−2.6	11.00	−0.45
Washington observatory.	.24	62.7	+0.4	11.55	+0.10
Duner	3.22	60.8	+0.4	10.57	−0.92
Washington observatory.	4.14	58.0	−0.6	11.39	−0.11
Duner	5.19	57.1	+0.5	10.73	−0.63
Washington observatory.	.23	56.2	−0.3	11.47	0.00
Washington observatory.	7.17	52.8	+0.1	11.35	+0.01
Burnham	.93	53.2	+2.0	10.71	+0.45
Burnham	8.03	51.1	+0.1	....	....
Cincinnati observatory	9.75	46.5	−0.9	10.29	−0.67
Holden	81.12	43.3	−1.2	10.83	+0.10
Washington observatory.	.26	45.3	+1.1	10.00	−0.50
Washington observatory.	2.18	42.2	+0.1	9.95	−0.13
Washington observatory.	23	42.5	+0.3	9.67	−0.43
Burnham	3.10	40.1	+0.4	9.05	−0.52
Young	.10	39.0	−0.7	9.41	−0.16
Hough	.12	39.7	0.0	9.02	−0.55
Washington observatory.	.17	41.4	+1.8	9.75	+0.20
Washington observatory.	.21	39.1	−0.3	9.26	−0.28
Hough	4.05	36.0	−1.1	9.67	+0.70
Hough	.17	36.7	−0.1	8.81	−0.09
Burnham	.19	36.4	−0.2	8.39	−0.45
Washington observatory.	.23	37.7	+1.1	8.81	+0.03
Paris observatory	.27	36.3	−0.2	8.70	−0.12
Paris observatory	5.11	34.1	+0.2	8.09	−0.04
Hough	.20	32.7	−0.9	7.96	−0.09

OBSERVER.	TIME.	$\theta o.$	$\theta o.-\theta c.$	R.	R. o.—R. c.
Washington observatory.	.27	34.7	+1.4	8.06	+0.10
Washington observatory.	6.14	30.6	+0.7	7.21	+0.20
Washington observatory.	.22	28.7	−0.8	7.39	+0.49
Young	7.14	25.4	+0.7	7.08	+1.58

As to angles, this comparison leaves little to be desired. Let us take the mean of the distances, observed minus calculated, by periods:

1st Period, 1862 to 1866	12	observations,	+0″.070
2d " 1866 to 1871	12	"	0″.000
3d " 1871 to 1882	12	"	−0″.114
4th " 1882 to 1888	18	"	+0″.024
Total mean	54	"	−0″.005

I see no occasion for the hypothesis of a third body disturbing the measures of this system. In fact, the measures for the most part are much more accordant with the calculated orbit than might reasonably be expected in the case of an object so difficult of observation.

Rochester, N. Y., Dec., 1887.

NOTES ON THE PROGRESS OF ASTRONOMY IN 1887.

DANIEL KIRKWOOD.

For the MESSENGER.

The Discovery of Asteroids. Seven minor planets were discovered in 1887, bringing the whole number at the close of the year up to 271. Their distances, dates of discovery, etc., are given below:

ASTEROID.	Date of Discovery.	Name of Discoverer.	Place of Discovery.	Mean Distance.
265 Anna	Feb. 25	Palisa	Vienna	2.4096
266 Aline	May 17	Palisa	Vienna	2.8078
267 Tirza	May 27	Charlois	Nice	2.7742
268	June 9	Borelly	Marseilles	3.0852
269	Sept. 21	Palisa	Vienna	2.6168
270 Anahita	Oct. 8	Peters	Clinton	2.1883
271	Oct. 16	Knorre	Berlin	3.0059

Anahita, No. 270, is very near the inner margin of the ring. Its period is 1184 days, and the plane of its orbit is nearly coincident with that of the ecliptic.

Comets. The first comet of 1887 was discovered by Dr.

Thome of Cordoba, January 18. It became, in the Southern hemisphere, a conspicuous object, with a tail at least 40° in length. The second of the year was first seen by Mr. W. R. Brooks, of Phelps, N. Y., January 22. Its elements have no special resemblance to those of any known comet. The third, fourth, and fifth comets of the year, were detected by Prof. Barnard, of Nashville, Tenn., on January 23, February 16, and May 3, respectively. The sixth comet of 1887, discovered by Mr. W. R. Brooks, on the morning of August 25, proved to be the Olbers' comet of 1815. This was its first predicted return.

New Nebulæ. The first volume of the History and Work of the Warner Observatory, Rochester, N. Y., was published in 1887. Dr. Swift's discoveries of Nebulæ, 540 in number, form an important part of this interesting report. The distinguished director is still engaged in his persevering search, which will be better appreciated, perhaps, in the future than at present.

FOR STUDENTS AND YOUNG OBSERVERS.

Interesting Objects and Phenomena for January.

THE PLANETS.

Mercury will be at superior conjunction, *i. e.*, on the opposite side of the sun from the earth, on the 18th, and is therefore not in favorable position for observation during the month. All of the other planets are in good position to be seen if one is willing to take the late hours of the night. Neptune may be observed in the early evening, Saturn through the whole night, Mars and Uranus after midnight, and Venus and Jupiter in the morning.

Neptune is the first to cross the meridian, and is about 6° directly south of the well-known group of the Pleiades, in a space where there are no stars brighter than the seventh magnitude. It will be difficult to recognize him with a telescope of less than six inches aperture, although he may be seen with a good opera glass.

Saturn comes next and is in excellent position for observation. The rings are inclined at an angle of about 20° to the line of sight. He may be found directly in the east at 8 P.

M., about a quarter of the way from horizon to zenith, forming a triangle with the two pairs of bright stars in Gemini (Castor and Pollux) and Canis Minor (Procyon and β Canis Minoris). A little east of Saturn is the Præsepe cluster of stars just visible to the eye, and easily resolved with an opera glass. Saturn will be at opposition on the 23rd; and in conjunction with the moon on the 28th at 8:20 A. M., so that at the time of the lunar eclipse that evening he will be a few degrees west of the moon.

Mars is in Virgo a few degrees northwest of the bright star Spica. His ruddy color enables one easily to recognize him. He will be in conjunction with the moon Jan. 6 at 3 A. M., south 2°46′.

Uranus is near Mars, and about 1° exactly south of the 3rd magnitude star θ Virginis, the nearest star northwest of Spica. He may be seen with an opera glass, and is easily recognized with a telescope of moderate power by his greenish hue and perceptible disk. He will be in conjunction with Mars, south 1°40′, Jan. 9.

Jupiter and *Venus* are near together in Libra, just a little northwest of the familiar constellation Scorpio. Jan. 2 Jupiter will be 1°51′ exactly south of Venus. Both of these planets are very conspicuous in the southeast at 5 A. M. Venus will move toward the east more rapidly than Jupiter and at the end of the month will be found in the upper part of the bow of Sagittarius, very close to the naked eye double star μ Sagittarii, in the edge of one of the brightest portions of the Milky Way. The phase of Venus is gibbous and increasing, the light now extending about 0.7 of the way across the disk.

NEPTUNE.

	R. A. H. M.	Decl.	Rises. H. M.	Transits. H. M.
January 1	3 43.0	+17°57′	1 46 P. M.	8 58.2 P. M.
January 15	3 42 1	+17 55	0 50 "	8 92.2 "
January 30	3 41.6	+17 54	11 51 A. M.	7 02.8 "

SATURN.

	R. A.	Decl.	Rises.	Transits.
January 1	8 28.9	+19 32	6 24 P. M.	1 43.4 A. M.
January 15	8 24.5	+19 49	5 23 "	12 43.8 "
January 30	8 19.5	+20 07	4 17 "	11 39.8 P. M.

MARS.

	R. A.	Decl.	Rises.	Transits.
January 2	12 52.4	−3 19	12 21 A. M.	6 06.1 A. M.
January 15	13 14.6	−5 27	11 57 P. M.	5 33.2 "
January 30	13 34.7	−7 17	11 25 "	4 54.2 "

URANUS.

	R. A.	Decl.	Rises.	Transits.
January 2	13 04.0	−6 06	12 43 A. M.	6 17.6 A. M.
January 15	13 04.6	−6 09	11 49 P. M.	5 23.2 "
January 30	13 04.5	−6 08	10 50 "	4 24.1 "

JUPITER.

	R. A.	Decl.	Rises.	Transits.
January 2	15 43.0	−18 50	4 16 A. M.	8 56.3 A. M.
January 16	15 53.4	−19 22	3 34 "	8 11.5 "
January 31	16 02.9	−19 49	2 47 "	7 22.0 "

VENUS.

	R. A.	Decl.	Rises.	Transits.
January 2	15 42.9	−16 59	4 08 A. M.	8 56.2 A. M.
January 16	16 50.6	−20 14	4 35 "	9 08.6 "
January 31	18 07.0	−21 54	5 00 "	9 25.9 "

While waiting for Saturn to rise into good position one may look at some of the other objects of interest to be seen in the early evening. Turning to the west the eye catches at once the four bright stars of the Square of Pegasus. The upper one of these four stars is α Andromeda (Alpheratz), and a little further up toward the zenith is β Andromeda. Turning almost at a right angle toward the northwest we see two fainter stars in line with β and beside the second one is a hazy patch of light. This is the great Nebula of Andromeda, a large oval mass of nebulosity, having in its centre a bright condensation like the nucleus of a comet. Almost directly east of the Andromeda Nebula, the second conspicuous star is β Persei or Algol, the noted variable star, which at intervals of about three hours less than three days, fades from 2nd to 4th magnitude for a few hours, resuming then its former brightness. The principal part of the constellation of Perseus is north of Algol in the Milky Way. Between Perseus and the familiar group of Cassiopeia's Chair, toward the northwest, is another large hazy patch of light. This is a splendid double cluster in the sword hand of Perseus. A little way east of the zenith is Capella, one of the brightest of the stars; toward the south, a little east of the meridian, Aldebaran, a very red star in the V-shaped group of the Hyades; and in the southeast, the finest of all the constellations, Orion, with the red star Betelgeux in one corner and the blue Rigel in the opposite corner of a quadrilateral, three stars between them forming the belt, and three the dagger suspended from the belt. The middle star in the dagger appears to the eye blurred or hazy. It is, in fact, not a star but the Great Nebula, one of the most wonderful objects in the heavens. In

its centre is a dark opening which contains four stars in the form of a trapezium, which may be seen with small telescopes. Southeast of Orion, near the horizon is Sirius, the Dog Star, brightest of all the stars.

DRAWING THE PLANETS.

For young observers who have the aid of good small telescopes, the study of the physical structure of the planets can not be advanced, probably, in any other way so well as by making numerous carefully executed sketches of the outlines of the planets, especially those of Mars, Jupiter, and Saturn. Take the case of Mars first, and suppose his disc subtends an angle of 17″, and that he is sufficiently near the earth to exhibit a phase that is perceptibly gibbous, like the moon two days before it is full. With a pair of compasses, from the centre C′ (Fig. 1) to a radius C′A, one-half inch, describe the circle ACBD. For any particular date, turn to the Nautical Almanac, and find, as in this case (Jan. 31), that 0.9 of that diameter of the planet passing through the sun is illuminated. Let CD be this diameter, and AB one at right angles. Then CE will be the part in light. First with center C′ as before, and radius C′D, describe the circle ACBD, measure off one-tenth of CD to E. Join AE, BE, and bisect AE in G and BE in H; from G draw GF at right angles to AE, and from H HF, at right angles to BE. Finally from F where these two lines intersect, and with radius FE describe the arc AEB; then will AEBC represent the outline of Mars sought, as he will appear on the last day of this month, with a diameter 9″.4. The phase will be well marked only when the planet is nearer the earth. This figure and method are taken from that excellent little book by Capt. Wm. Noble of England entitled "Hours with a Three-inch Telescope." The drawings for Saturn and Jupiter will be given next time.

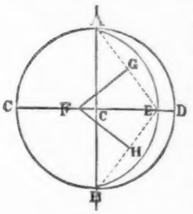

FIG. 1.

The Opera Glass is an inexpensive instrument, but it is a helpful one in the study of astronomy, and it is a wonder that teachers of astronomy in any grade of school, do not make more use of it. It is our purpose in the next number of the

MESSENGER to give a few examples of its uses in viewing celestial objects, in the hope of awakening general interest in this mode of study. A plan of regular instruction will be furnished to those who desire it on terms and conditions that involve continuous and useful observation. Correspondence is solicited.

Sun-Glows.— From February, 1886, to February, 1887, peculiar color after sunset was seen 67 times, and classed as follows:

3	times	marked	rich.
9	"	"	considerable.
55	"	"	some.

From February, 1887, to August, 1887, color was seen 22 times:

3	times	marked	considerable.
19	"	"	some.

Various writers have frequently alluded to the bad state of the atmosphere for astronomical observations during the entire period of these sun-glows. That trouble has apparently passed. J. R. H.

Baltimore, Dec. 13, 1887.

A Bright Meteor was seen by J. E. Keeler, of Lick Observatory, on the night of Oct. 18th. Its path was towards the south, nearly in line with α and β Orionis. It passed about a degree above ν^1 Eridani and disappeared five degrees beyond. Its light was a brilliant pale green. Its bright train was visible in a small glass for more than twenty minutes.

Mr. Geo. H. Peters, of Hartford, saw a meteor, Oct. 19th, $10^h\ 49^m$, brighter than Jupiter and of a pale green color. It first appeared near ε Orionis, moved in a slightly curved line towards the horizon, between η and β Orionis, disappearing about 4° beyond. Careful observations of the bright meteors give useful data for obtaining altitude and the elements of their orbits.

Meteors. On the night of Dec. 11th, my attention was attracted by the number of meteors which originated in Orion. Between the hours of 9 and 9:30 P. M., I saw twenty-four.

The direction was from N. E. to S. W. I continued my observations at the same time on the following evening and counted twenty-one. On the evening of the 16th the radiant point was about one degree north-east of Betelgeuse. The color of most was bluish white; some were red, and some had well-defined trails. Most of the meteors moved southward.

San Francisco, Dec. 16, 1887. MONTE KOSHLAND.

Total Eclipse of the Moon. At the time of full moon on January 28, the moon will pass through the shadow of the earth and will be totally eclipsed for an hour and thirty-eight minutes. This eclipse in some of its phases will be visible throughout most of the inhabited part of the world. In the western part of the United States the first phases will not be seen, but the moon will rise totally eclipsed, and the last phases may be observed.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, 28d 11h 22m 03.6s

Sun's right ascension	20h 43m 52.65s	Hourly motion	10.31s
Moon's " "	8 43 52.65	" "	142.56
Sun's declination	18° 08′ 11.9″ S.	" "	0′ 39.7″ N.
Moon's "	18 01 43.2 N.	" "	5 52.5 S.
Sun's equa. hor. parallax	9.0	S.'s true semidiam	16 14.4
Moon's " "	58 11.1	M.'s " "	15 50.6

TIMES OF THE PHASES.

		Washington Mean Time. H. M.	*Central Time. H. M.
Moon enters penumbra	January 28,	3 19.5	2 27.7
Moon enters shadow		4 22.2	3 30.4
Total eclipse begins		5 22.7	4 30.9
Middle of the eclipse		6 11.9	5 20.1
Total eclipse ends		7 01.0	6 09.2
Moon leaves shadow		8 01.3	7 09.5
Moon leaves penumbra		9 03.7	8 11.9

Magnitude of the eclipse = 1.647, (moon's diameter = 1).

OCCULTATIONS VISIBLE AT WASHINGTON.

Date.	Stars Name.	Magnitude.	IMMERSION. Wash. Mean Time. H. M.	IMMERSION. Angle fr'm N. P't. °	EMERSION. Wash. Mean T. H. M.	EMERSION. Angle f'm N. P't. °	Duration. H. M.
Jan. 1	7 Leonis	6½	81 59	161	19 38	340	0 39
3	B. A. C. 3837	6½	11 47	66	12 36	333	0 49
7	ξ^1 Libræ	6	15 16	177	15 45	231	0 28
15	ι Aquarii	4½	7 36	137	8 27	264	0 51
21	μ Ceti	4½	7 25	53	8 51	257	1 26
25	χ^3 Orionis	6	5 24	46	6 24	289	0 59
25	68 Orionis	6	10 35	97	12 00	261	1 25
31	b Virginis	5½	16 22	93	17 29	324	1 07

* Six hours from Greenwich.

PHASES OF THE MOON.

	Washington Mean Time.	H.	M.
Last Quarter..	January 5,	18	34.2
New Moon..	January 12,	15	30.4
First Quarter..	January 20,	11	40.9
Full Moon..	January 28,	6	10.7

MIMIMA OF ALGOL (β Persei; R. A. 3h 01m, Decl. + 40°31′).

	Central Time. D.	H.	M.		Central Time. D.	H.	M.		Central Time. D.	H.	M.
January	3	00	55	January	14	12	10	January	25	23	26
	5	21	43		17	8	59		28	20	15
	8	18	32		20	5	48		31	17	04
	11	15	21		23	2	37				

GREAT RED SPOT ON JUPITER—TIMES WHEN ITS ZERO MERIDIAN PASSES THE CENTRE OF JUPITER'S DISC.

	Central Time. D.	H.	M.		Central Time. D.	H.	M.		Central Time. D.	H.	M.
January	1	18	04.1	January	12	12	13.7	January	22	20	27.1
	2	13	55.6		13	18	00.9		23	16	18.6
	3	19	42.9		14	13	52.4		24	12	10.1
	4	15	34.4		15	19	39.6		25	17	57.2
	5	21	21.6		16	15	31.1		26	13	48.7
	6	17	13.2		17	21	18.3		27	19	35.8
	7	13	04.7		18	17	09.8		28	15	27.3
	8	18	51.9		19	13	01.3		29	21	14.4
	9	14	43.5		20	18	48.5		30	17	05.9
	10	20	30.7		21	14	40.0		31	12	57.3
	11	16	22.2								

EDITORIAL NOTES.

Our new volume begins with this number, in a new dress, from new type, and a new printing office. We, therefore, hope that our New Year greeting to all our readers is a peculiarly happy one.

Subscribers will please notify the publisher promptly if the continuance of the MESSENGER for the ensuing year, or beyond paid subscription, is desired; otherwise it will not be sent. If annual subscriptions be paid during the month of renewal, two dollars only, as usual, will be charged; if paid later the annual fee will be $2.50.

We take pleasure in announcing that our next issue will contain an illustrated article showing the present condition and the prospects of the great Lick observatory, at Mt. Hamilton, California. Though exceedingly busy, as every one must suppose President Holden at present to be, he has kindly consented to prepare the article himself.

Orbits of Meteors. The following orbits I have computed from well defined radiants deduced by Mr. W. F. Denning from observations in September, and published in the *Observatory* for November, 1887, p. 384. Several of these radiants have been confirmed by observations in previous years:

Current Number.	Longitude of Perihelion.	Longitude of Node.	Inclination.	Perihelion Distance.
1	106.9°	173.3°	5.7°	0.300
2	87.7	175.2	67.4	0.478
3	24.6	174.3	85.6	0.932
4	94.7	175.2	127.3	0.418
5	52.2	173.3	178.5	0.758
6	43.4	177.2	51.0	0.846
7	49.5	173.3	69.5	0.778

O. C. WENDELL.

Harvard College Observatory, Dec. 15, 1887.

Lunar Photography. Mr. H. C. Maine, associate editor of the Rochester N. Y. *Democrat and Chronicle*, and an enthusiastic astronomer, has recently produced some excellent work in lunar photography. The negatives were made in the principal focus of a silver-on-glass reflecting telescope constructed by Mr. Maine. The speculum is thirteen inches in aperture and seventy-eight inches focal length. A Barlow lens, or amplifier is placed a few inches inside the focus of the mirror, by which a direct image of the moon about 1¾ inches in diameter is obtained. The telescope is mounted as a Newtonian, and on an alt-azimuth stand. Clock-work for driving the telescope is therefore inapplicable, and the exposures are instantaneous by means of a simple drop shutter.

The writer recently had the pleasure of examining some of the original negatives and also contact and enlarged prints from the same, and their sharpness and detail were surprising. The enlargements (fifteen inches in diameter) were on "argentic paper"—a modification of bromide paper—and represented the moon near the half and full phases. They were exhibited at a recent meeting of the Rochester Academy of Sciences, at which time Mr. Maine read a paper on the history and practice of lunar photography. He has for several years made photographs of the sun, and his work ranks with the very best that has been produced in this line. W. R. B.

Red House Observatory, Dec. 1887.

The Equatorial Telescope. The objection to the use of the prism, that the position of the objects in the field depends upon the angle at which the prism is placed, I have found to be entirely obviated by placing the prism at right angles with the polar axis, facing towards the pillar, and never changing its position. Suppose the telescope to the east of the pillar; in observing objects in the meridian the eye looks horizontally towards the west. As the objects pass toward the west, the eye looks more and more downward, until the depression equals the complement of the latitude; but it never exceeds this. When the telescope is reversed, the prism is in position for equally convenient observation towards the east.

The finder should be upon the same side of the large telescope with the prism eyepiece; when it will always be at hand, in whatever direction the telescope is pointed. Both in variable star comparisons, and in photometric work, I have required unusually large finders, which have been placed below the line of the declination axis, making it impossible to balance the telescope with the sliding weight. I have recently attached a short rod with a small sliding weight, at right angles with the telescope, and in the meridian. With this I can balance the finder; and the telescope is then in adjustment for all positions. At first I attached this additional counterpoise to the saddle on the side towards the eye; but it sometimes interfered with the stand, and I have found it less in the way on the other side of the saddle. It would be still less in danger of interference with the stand if attached to the tube nearer the end; but it is my impression that it would be better still to have the finder in the line of the declination axis, the additional convenience from placing it on one side not being sufficient to offset the disadvantages of a counterpoise. HENRY M. PARKHURST.

Brooklyn, N. Y., Dec. 15, 1887.

New Nebulæ at the Warner Observatory. On May 23rd of the present year, the sixth catalogue, of one hundred each, of nebulæ discovered at this observatory was mailed to the editor of the *Astronomische Nachrichten*, and published in No. 2798 of that journal. It was then expected that, ere this, another list, containing a like number, would be ready for

publication, but, during the last eight months, the weather, which has been more unfavorable for work so delicate than for thirty years past, has prevented its completion. However, since the printing of No. 6, sixty-six, not previously known, have been found, most of which are recorded in Dr. Dreyer's new General Catalogue of Nebulæ, containing all known nebulæ up to date, July 1, 1887, when it went to press. The printing of Dr. Dreyer's list, which contains in the body of the work 7840 numbers, is in a forward state, having, on Sept. 1, reached 7*h* 1*m*. The book will be found one of the most valuable astronomical publications of the century.

It was formerly supposed that because the heavens had been so thoroughly searched by the Herschels, D'Arrest and others, the quest for new ones would be an almost fruitless one, indeed, time well nigh lost, but the numbers since discovered by Tempel, Stephan, Stone and at this observatory, show that the nebulæ, like the stars, are inexhaustible. As a matter of course, those that remain must be exceedingly faint, requiring not only a large telescope, a keen eye long trained to the search, and exceptionally fine seeing, but also an eyepiece constructed expressly for this work.

The writer has found all of Sir William Herschel's faintest nebulæ—his class III.—easy objects. A short time ago while sweeping near Alpha Lyra, it was desired to observe one of his faintest nebulæ (No. 4417 of Sir John's G. C. of nebulæ) near that star. It was found much brighter than expected, and, strangely enough, two others were seen which he had overlooked, one on either side, and not over three or four minutes of arc apart. One of them is so exceedingly faint, it is not surprising that it should have escaped his observation. Its place for 1890 is R. A. 18*h* 26*m* 15*s*, Dec. + 39° 55′ 5″. It is described, in the director's note-book, as "Exceedingly, exceedingly, exceedingly faint, pretty small, little elongated, three stars in line point to it, in finder field with Vega." It is, however, more to be wondered at that Herschel failed to detect the other, as it is as bright as his own, though very much smaller. Just previously, Edward, the director's seventeen year old son and his occasional and only assistant, had discovered another almost as near Vega. Stephan, also, has one near. A few months since a new one was picked up in finder field with the Dog Star, of which no published re-

cord exists. But stranger than these, the young tyro mentioned above, found one, and his father, a second, in finder field with Epsilon Lyræ, that wonderful double-double which has been a target for all the great telescopes of the world, and which astronomers have scanned without suspicion that two undiscovered nebulæ were near. That, seen by the younger observer was the fainter of the two, he overlooking the brighter one subsequently captured by his father.

A few years ago, while sweeping, the thought of the possibility of faint, undiscovered nebulæ being in close proximity to some of the bright stars occurred, and, Delta Leonis chancing to be near, the telescope was turned on it, and a pretty faint, new nebula was found 6′ or 8′ from it. Encouraged by this success, the search was continued, though nearly a year elapsed before another was thus found, the last being in the field with Algol. Several close doubles have been found here, the duplicity of one which was suspected with a power of 132, having been fully confirmed with 200, and well separated with 350. A triple nebula with components near enough to be ranked as a triplet proper, cannot be claimed among the discoveries of this observatory.

Doubtless many nebulæ yet remain to be detected. Probably several thousand will be discovered from our present position in space by the great telescopes of to-day.

Warner Observatory, LEWIS SWIFT.
Rochester, N. Y., Dec. 15, 1887.

Observatory of Nice. Volume II. of the "Annales de l'Observatoire de Nice" has recently been published under the auspices of the Bureau of Longitudes of France by the director of the observatory, M. Perrotin. The first volume, containing the description of the observatory and the instruments, is in preparation. The third volume will contain drawings of the solar spectrum by M. Thollon, which are in the hands of the engraver.

Volume II., which we have in hand, is a large quarto ot about 440 pages with a number of engravings and seven large and finely executed plates. The first part contains the details and discussion of the determination of the difference of longitude between Paris and Nice, and Milan and Nice, in September and October 1881, by MM. Bassot, Perrotin and

Celoria. An interesting point here is the determination of personal equation between the observers Bassot and Perrotin by exchanging stations and also by means of a personal equation machine, the two methods giving respectively B.—P. = +0.125*s* and +0.100*s*. The following parts contain provisional determinations of the latitude in 1882 and 1884 by M. Perrotin; a long series of double star measurements, principally of the Dorpat and Poulkova catalogues, made by M. Perrotin, from 1883 to 1887, with the 0.38 metre or 15-inch equatorial; micrometric observations of comets and planets by MM. Perrotin and Charlois; physical observations of the comet Pons-Brooks, great comet of 1882, Uranus, Saturn, and Mars; solar spectroscopy, by M. Thollon; and a number of miscellaneous papers by Thollon, Puiseux, Perrotin and Charlois. Some of these papers are very interesting and valuable and altogether the volume is one to be highly prized by those fortunate enough to secure it. H. C. W.

Syracuse University Observatory. The dedication of the the new observatory of the University of Syracuse, N. Y., took place Nov. 18, 1887, with appropriate ceremonies. The formal address prepared for the occasion was given by Prof. Newcomb and part of it appears elsewhere in this number. The building stands on a hill to the west of the Hall of Languages, and is built of rough dressed Onondaga lime stone. The transit instrument was made by Troughton & Simms, of London. It has a telescope of three inches aperture and forty-two inches focus. The chronograph is by Fauth & Co., Washington, chronometer by Dent, of London, and sidereal clock is being made at Dresden, Germany. The equatorial telescope has eight inches clear aperture and was made by the Clarks, of Cambridgeport, Mass. Upon the wall in the reception room is a neat tablet bearing the following inscription:

This observatory was erected and equipped in memory of Charles Demarest Holden, a graduate of Syracuse University in the class of 1877. Born at Charlotteville, N. Y., June 10, 1853. Died at Syracuse, N. Y., February 21, 1883.

The new observatory will be under the direction of Prof. John R. French whose earnest work in this department of science well deserves these fine added facilities.

Messrs. Fauth & Co., of Washington, D. C., have completed the micrometer for the great equatorial of Lick Observatory. Its weight is forty-five pounds. From the photograph of it which the company very kindly sent us recently, it must be a very complete and finely finished piece of mechanism. President Holden will doubtless speak of it later more particularly.

We are not surprised to know that this enterprising firm have largely increased the capacity of their shops and are still crowded with orders for expensive astronomical instruments of various kinds. They have just completed a meridian circle for Greencastle, Indiana, another for Johns Hopkins University, and several special instruments for Thomas A. Edison. They are now making a meridian circle with telescope of five inches aperture and circles thirty inches in diameter for the Cincinnati observatory. Such patronage from the older observatories who know these makers best from the excellent work they have done is evidence of solid and deserved merit. From new and increased facilities astronomers and scientists will be glad to learn that Messrs. Fauth & Co. propose to make circle mountings a specialty and they are now prepared to do work of this kind of the best quality.

The Ring Nebula in Lyra. According to a communication from R. Spitaler of the Vienna observatory, to the "Zeitschrift für Populäre Astronomie Sirius" the existence of a variable star near the centre of the ring nebula in Lyra seems to be fairly established. He says:

"In consequence of the announcement from Herr E. von Gothard, of the probable existence of a ring shaped nucleus near the centre of this nebula, I examined this object, with the aid of the large refractor of this observatory, during the latter part of September and beginning of October, 1886.

"Any change in the appearance of the same I should have at once detected because of my careful examination while making an accurate drawing of this nebula during September, 1885. I utterly failed to detect any change in comparison with my drawing.

"With low powers the inner portion of the ring appears covered with a delicate luminous veil, while higher powers bring out different intensities of light, giving this inner por-

tion a flaky appearance. Nearly west from the centre such a flake is commonly visible. In the eastern portion of the inner ring plane, and near the edge I have frequently seen three faint stars. While infinitesimal points of light flashed momentarily into view in other parts of the nebula, no star could be detected near the centre. This was corroborated by Prof. Vogel in Potsdam and photographically by the Henry brothers in Paris (A. N., 2754). On the 25th of July Prof. Young, of Princeton, visited us, and on this occasion we looked up several objects with the large refractor. The atmosphere was not all that might be desired, still the seeing was fair.

"When we pointed the telescope upon the ring nebula, I was astonished to find, at first sight, a little star near the middle of the inner ring plane, a little north west of the centre, and exactly as shown in the Gothard photograph (a diapositive of which was kindly sent us), only that it appeared proportionally fainter than the photograph.

"On July 26, although the sky was not absolutely clear, I again saw this star, but not as readily as the previous night. Undoubtedly we have a variable here which deserves some attention.

"Concerning the visibility of this star, of which Hahn first made mention in the Berliner Jahrbuch of 1803, there are several other recorded observations (see remarks in A. N., 2754). To the dates collected by Holden (Monthly Notices, Vol. 36 p. 36) should be added that Prof. Young and Mr. R. D. Schimpff, while examining this nebula Aug. 26, 1884, with the 23-inch refractor of the Princeton observatory, also noted a minute star near the centre (Sirius, Vol. XIII., p. 142.) Prof. Young informed me that he, in company with Barnard, again saw this star last year."

Dr. Klein adds that in view of Mr. Spitaler's communication he examined this nebula with his 6-inch refractor, Aug. 23, the atmosphere being exceptionally clear and steady. He was unable to take the star. He admits, however, that with the aid of his instrument it is impossible to pick out, from the fluctuating ground of the nebula, a star of the tenth magnitude and concludes that, at the time of his observation no star of the 9.5 magnitude, or brighter, was near the centre of this nebula. R. D. S.

Corrections of Catalogues of Nebulæ. Dr. Swift notes (*Astr. Nach.*, 2798) that Nos. 2 and 7 of the sixth catalogue of nebulæ discovered at the Warner observatory are identical with Nos. 277 and 303 of the second list of nebulæ observed at the Leander McCormick observatory (*Astr. Jour.*, 152). Corrections to the Warner observatory third and fifth and sixth catalogues appear, respectively, in the *Astronomische Nachrichten*, No. 2746, and the SIDEREAL MESSENGER, Nos. 52 and 59. These corrections with those given here make, I think, a complete list of corrections to the first six Warner observatory catalogues so far as nebulæ between 0° and 30° south declination are concerned; corrections to the other nebulæ are not given because this observatory has not a list of all the published northern nebulæ.

The numbers given below in the first column are those of the Warner observatory catalogues numbered continuously; the third column contains the number of the nebula as previously published:

25	e F, p s, l E	G. C. 3657	F, S, R
162	p F, neb $*_*$	G. C. 4395	F, p L, e E, $*_*$ inv.
261	p B, v S, R	Washburn Obs. I, No. 6	p F, *11.5 nf 30″
263	v F, p S, R	G. C. 2846	v F, p L, i F
271	e F, p S, R	G. C. 3510	e F, e S, i R

The southern nebulæ in the third catalogue of the Warner observatory have, by an oversight, been until now omitted from the Leander McCormick observatory's general list of southern nebulæ, consequently it was not noticed that Nos. 352 and 359 were identical with Nos. 223 and 229 of the third catalogue; Nos. 352 and 359 should therefore be erased from the second list of nebulæ observed at the Leander McCormick observatory (*Astr. Jour.*, 152). Dr. Swift has a fainter nebula, 3′ sf No. 223, which was not observed here.

Leander McCormick Observatory, FRANK MULLER.
University of Virginia, Nov. 25, 1887.

Dudley Observatory, at Albany, N. Y., is a historic place that we have longed to see. That hope was realized in August last. Though Professor Boss was absent in Europe at the time, his genial assistant, H. V. Egbert, was at the helm and ready for any emergency. Those instruments having the pattern of early days and bearing the marks of long use, are indeed objects of curious interest. All honor to them for

the good work they have done, but it is not now a question of debate whether some of them ought to be retired for life or not. In one corner was seen a relic of the reign of Professor Hough, that first pattern of the printing chronograph. No one can tell its age, yet it is believed to be the parent of the Hough Printing Chronograph of to-day that may soon displace all others. Beside this antique piece was the first model of the Mitchel chronograph, with revolving disc, another specimen of American antiquities in astronomical lines that has already had a noble history. But that large calculating machine on the other side of the room is too much for ordinary descriptive powers. The mute visitor wonders if Professor Boss ever shapes his modern calculations by that engine. It doubtless has a history also.

Our friend Mr. Egbert showed us the excellent library of the observatory and its appointments for work, and gave full information of his nightly occupation with meridian circle observations, places of comets, and general routine work. His clock tests, mode of reductions, and orbit calculations were instructive and contained several points that were new.

Catalogue of the Observatory of Paris. A note by Admiral Mouchez (extract from "Comptes rendus de sèances de l' Academie des Sciences, CV., Oct. 17, 1887") gives interesting information concerning the forthcoming catalogue of the Observatory of Paris, which is a revision of the catalogue of 47,390 stars observed under the direction of Lalande, from 1791 to 1800. Le Verrier decided to undertake this revision, in 1854. In order to obtain all the precision considered necessary to-day, he fixed upon three observations of declination and three of right ascension as the determination of each star; this was without doubt a very just appreciation of the actual needs of astronomy, but it imposed upon the Observatory of Paris an enormous work of 300,000 meridian observations, which, to be made under the best conditions, must be executed very rapidly.

Unfortunately, the Paris sky, generally unfavorable to a long series of observations, the insufficient means at Le Verrier's disposal, and the important works of celestial mechanics, to which he then consecrated the greater part of his time, did not permit him, to his great regret, to push the revision of

the catalogue of Lalande with all the necessary activity, and when Admiral Mouchez was called to the direction of the observatory in 1878, there were hardly more than a third of the necessary observations made. Since 1879 this work has been pushed more vigorously, so that the annual number of meridian observations has been raised from an average of from 6,000 to 8,000 up to 25,000 or 28,000.

The printing of the first two volumes of the new catalogue was begun in 1884. In order not to delay the publication, it has been decided not to wait until the completion of the observations; the first part, which is being published now, comprises only the stars observed up to 1881; the rest will appear in a complementary volume as soon as the first part is finished. The first two volumes contain all the stars comprised between 0*h* and 6*h* right ascension to the number of 7,245, for which 80,000 observations were made in right ascension and declination.

One of the volumes contains the catalogue proper; the other all the observations used in forming it.

The preparation of the following volumes is being actively carried on and will be continued without interruption until the completion of the work.

The Lick Observatory Prosperous. Not long ago a painful report was in circulation, (starting so far as we know in the far East) that the great Lick observatory was likely, after all, to fail for lack of funds, for running expenses, nearly all of its $700,000 having been expended in the erection of buildings and the purchase of instruments. This is certainly far from the truth, in the light of recent action by the legislature of the state and the regents of the University, from which sources $19,000 have already been appropriated for the running expenses of the observatory for the year 1888. That comfortable little sum of money will certainly give a generous start for the first year.

It is indeed a good sign of progress that so many colleges are furnishing small observatories for the purpose of instruction in astronomy; and colleges and seminaries for ladies are not behind others in this respect. Miss Mitchell of Vassar, Miss Bardwell of Mt. Holyoke, Miss Byrd of Smith, and Miss

Hayes of Wellesly, who is now studying practical astronomy at the Leander McCormick observatory, are worthy examples of the true preparation for right instruction in this noble science.

Recent letters from California say that Mr. Charles B. Hill of Chabot Observatory has been chosen to a position in Lick Observatory, that Alvan G. Clark of Cambridgeport, Mass., arrived at San Francisco Dec. 13, bringing with him the 36-inch photographic corrector which he has made for the great telescope of the observatory, and that Mr. Swasey, of Cleveland, of the firm which made the mounting for the great equatorial, is also there. Mt. Hamilton will be a lively place from this time onward.

Report of U. S. Naval Observatory. The report of the superintendent of the United States Naval Observatory, Capt. R. L. Phythian, for the year ending June 30, 1887 is at hand. The only important change noticed in the personnel of the observatory is in the office of superintendent, which took place in November 1886, at which time Capt. Phythian succeeded Commander Allan D. Brown. The substance of the report of general public interest has already received notice at various times.

Prof. Frank H. Bigelow, of Racine College, has recently given a course of popular lectures on astronomy, before the Racine Academy of Arts, Sciences and Letters, on the following themes:—

The Coördinates of Astronomy, Instruments for Star Positions, Astro-physical Instruments, The Earth's Atmosphere, The Sun's Atmosphere, and Some Important Corrections.

M. D. Ewell, of Chicago, has been giving some attention to apparatus for the study of physical standards. As an important step in this direction, the Northwestern University has furnished Mr. Ewell with a large Rogers' comparator which is already mounted and said to be a most perfect instrument of its kind.

All scientists who do not already know the fact, will be glad to learn that Prof. S. P. Langley, formerly director of Allegheny Observatory, has been elected Secretary of the

Smithsonian Institution at Washington, to succeed the late Prof. Spencer F. Baird. The choice was an excellent one.

Zusatz-Sterne in Auwers' System. For two months past Prof. Brown has been using the meridian circle of Washburn Observatory, Madison, Wis., on the determination of fundamental star-places of the Zusatz-sterne in Auwers' system, undertaken at the request of Prof. Auwers himself. Prof. Brown holds the position of Professor of Mathematics in the Navy, was formerly at the Naval Observatory, went thence to the Naval Academy at Annapolis, Md., to work with the Meridian Circle at that place, thence he was detailed to Washburn Observatory.

BOOK NOTICE.

Easy Lessons in the Differential Calculus, Indicating from the Outset the Utility of the Processes called Differentiation and Integration. Richard A. Proctor, Longmans, Green & Co., London, and New York 15 East 16th Street, 1887, pp. 114.

This book contains the essentials of the Differential Calculus well arranged for elemental study. It gives a series of twenty-one easy lessons, showing first the purpose of this interesting branch of mathematics and then its relation to the Integral Calculus. The main object of the writer is to show the student the real uses of these branches of study, while he is attempting to master elemental principles and methods peculiarly their own, and hold his attention to these things, neglecting as useless, if not hurtful, much of the details which are found in ordinary text-books. The author then states and proves the rules for work and applies them to all the topics ordinarily presented in the elementary calculus illustrating each with appropriate exercises, the solutions of which are fully given. The book is evidently not intended as a text-book, for school or college use, in the sense of furnishing sufficient exercise in the application of the elements of the calculus; but it will be found very useful in review of principles, helpful in the meaning of operations, and instructive in the theories of limits and infinitesimals which so often trouble writers and teachers to explain. We think the author rightly combines the two opposing methods of limits and infinitesimals thereby practically escaping the bald fiction of the one and bridging the dark chasm of the other.